10/686,788

WHAT IS CLAIMED IS:

1. A switching circuit device comprising:

a substrate comprising an insulating region;

a first field effect transistor, a second field effect transistor, a third field effect transistor and a fourth field transistor, each of the first, second, third and forth transistors comprising a source electrode, a gate electrode and a drain electrode;

a common input terminal connected to the source electrodes or the drain electrodes of the first and second transistors;

a first output terminal connected to the source electrode or the drain electrode of the first transistor, which is not connected to the common input terminal, and connected to the source electrode or the drain electrode of the third transistor;

a second output terminal connected to the source electrode or the drain electrode of the second transistor, which is not connected to the common input terminal, and connected to the source electrode or the drain electrode of the fourth transistor;

a first control terminal connected to the gate electrodes of the first and fourth transistors;

a second control terminal connected to the gate electrodes of the second and third transistors;

a high-frequency ground terminal connected to the source electrodes or the drain electrodes of the third and fourth transistors, which are not connected to the corresponding output terminals; and

a protecting element comprising a first high concentration impurity ~~region~~, a second high concentration impurity region and at least part of the insulating region of the substrate, said part of the insulating region being located between the first and second high concentration impurity regions,

wherein the protecting element is connected between the first output terminal and the gate electrode of the third transistor or between the second output terminal and the gate electrode of the fourth transistor and is configured to discharge at least partially electrostatic energy of external origin through the protecting element so that the electrostatic energy is reduced enough not to provide an electrostatic breakdown voltage between the gate electrode and the corresponding source or drain electrode of the transistor that is connected to the protecting

element.

2. The switching circuit device of claim 1, wherein the protecting element is configured to increase an electrostatic breakdown voltage between the gate electrode and the source electrode or the drain electrode of the transistor that is connected to the protecting element by approximately 20 volts from the electrostatic breakdown voltage of the corresponding transistor without the protecting element.

3. The switching circuit device of claim 1, wherein an electrostatic breakdown voltage of the switching circuit device is 200 volts or higher.

4. The switching circuit device of claim 1, wherein the protecting element is disposed along at least one side of a bonding pad of the corresponding output terminal.

5. The switching circuit device of claim 1, wherein the first high concentration impurity region is connected to a bonding pad of the corresponding control terminal or to a wiring line connected to the bonding pad.

6. The switching circuit device of claim 1, wherein the first high concentration impurity region is part of a resistor connecting a bonding pad of the corresponding control terminal and the gate electrode of the corresponding transistor.

7. The switching circuit device of claim 1, wherein the second high concentration impurity region is connected to a bonding pad of the corresponding output terminal or to a wiring line connected to the bonding pad.

8. The switching circuit device of claim 1, wherein the second high concentration impurity region is part of a third high concentration impurity region that is disposed adjacent a bonding pad of the corresponding output terminal or a wiring line connected to the bonding pad or is disposed below the bonding pad or the wiring line.

9. The switching circuit device of claim 1, wherein the insulating region is an impurity ion implanted region formed in the substrate.

10. The switching circuit device of claim 1, wherein the substrate is a semi-insulating substrate.

11. The switching circuit device of claim 1, wherein an impurity concentration of the insulating region is 1×10^{14} cm^{-3} or lower.

12. The switching circuit device of claim 1, wherein a separation between the first and second high concentration impurity regions of the protecting element is small enough for the discharged electrostatic energy to pass through.

13. The switching circuit device of claim 1, wherein impurity concentrations of the first and second high concentration impurity regions are 1×10^{17} cm^{-3} or higher.

14. The switching circuit device of claim 1, wherein a resistivity of the insulating region is 1×10^{3} $\Omega \cdot cm$ or higher.

15. The switching circuit device of claim 1, further comprising a metal electrode connected to a bonding pad corresponding to one of the terminals or to a wiring line connected to the bonding pad, wherein the first high concentration impurity region or the second high concentration impurity region is connected to the metal electrode.

16. The switching circuit device of claim 15, wherein the metal electrode forms a Schottky junction with the first or second high concentration impurity region that is connected to the metal electrode.

17. The switching circuit device of claim 15, wherein the metal electrode forms a Schottky junction with a surface of the insulating region at position that is away from an edge of the first or second high concentration impurity region that is connected to the metal electrode by

up to 5 μm.

18. The switching circuit device of claim 1, wherein the transistors are metal-semiconductor field effect transistors, junction field effect transistors or high electron mobility transistors.

19. The switching circuit device of claim 1, wherein the first and second high concentration impurity regions are embedded in the insulating region of the substrate and a width of the first impurity region is smaller than a width of the second impurity region so that upon a start of discharging process of the electrostatic energy through the protecting element a first current path for electron or hole is formed in the insulating region between opposing faces of the first and second high concentration impurity regions and between bottom faces of the first and second high concentration impurity regions and that a second current path for electron or hole is formed in the insulating region between the bottom face of the second high concentration impurity region and another side face of the fist high concentration impurity region, the second current path being deeper than the first current path.

20. The switching circuit device of claim 19, wherein the first high concentration impurity region is connected to an extension part so that upon the start of discharging process of the electrostatic energy through the protecting element a third current path for electron or hole is formed in the insulating region between the extension part and the second high concentration impurity region.

21. The switching circuit device of claim 1, wherein the first and second high concentration impurity regions are embedded in the insulating region of the substrate and a width of the first impurity region is substantially equal to a width of the second impurity region so that upon a start of discharging process of the electrostatic energy through the protecting element a first current path for electron or hole is formed in the insulating region between opposing faces of the first and second high concentration impurity regions and between bottom faces of the first and second high concentration impurity regions and that a second current path for electron or hole is formed in the insulating region between the another side face of the second high

concentration impurity region and another side face of the fist high concentration impurity region, the second current path being deeper than the first current path.

22. The switching circuit device of claim 21, wherein the first high concentration impurity region is connected to an extension part so that upon the start of discharging process of the electrostatic energy through the protecting element a third current path for electron or hole is formed in the insulating region between the extension part and the second high concentration impurity region.

23. The switching circuit device of claim 22, wherein the second high concentration impurity region is connected to another extension part so that upon the start of discharging process of the electrostatic energy through the protecting element a fourth current path for electron or hole is formed in the insulating region between said another extension part and the first high concentration impurity region.

24. The switching circuit device of claim 19 or 21 , wherein the width of the first high concentration impurity region is 5 μm or smaller.

25. The switching circuit device of claim 19 or 21, wherein a conductivity modulation efficiency of the second current path is at least 5 times higher than a conductivity modulation efficiency of the first current path.

26. The switching circuit device of claim 19 or 21, wherein an amount of current that passes through the second current path is equal to or greater than an amount of current that passes through the first current path.

27. The switching circuit device of claim 19 or 21, wherein the second current path is formed to extend from an edge of the first impurity region by at least 10 μm.

28. The switching circuit device of claim 19 or 21, wherein the second current path is formed is formed away from the bottom faces of the first and second high concentration impurity

regions by at least 20 μm.

29. The switching circuit device of claim 19 or 21, wherein the second current path is configured to expand in response to an increase of the discharged electrostatic energy so as to increase a conductivity modulation efficiency of the second current path.

30. The switching circuit device of claim 19 or 21, wherein the first and second impurity regions are connected so as to increase an electrostatic breakdown voltage of the corresponding transistor by ten times or more from the electrostatic breakdown voltage of the corresponding transistor without the connection, a parasitic capacitance between the first and second impurity regions being 40 fF or smaller.

31. The switching circuit device of claim 20, 22 or 23, wherein a conductivity modulation efficiency of the third current path is at least 5 times higher than a conductivity modulation efficiency of the first current path.

32. The switching circuit device of claim 20, 22 or 23, wherein the third current path is formed to extend from the extension part by at least 10 μm.

33. The switching circuit device of claim 20, 22 or 23, wherein the third current path is configured to expand in response to an increase of the discharged electrostatic energy so as to increase a conductivity modulation efficiency of the third current path.

34. The switching circuit device of claim 1, wherein the first and second high concentration impurity regions are embedded in the insulating region of the substrate and a width of the insulating region adjacent a back side face of one of the first and second high concentration impurity regions is 10 μm or larger, the back side face being opposite from a front side face of said one of the first and second high concentration impurity regions which faces the part of the insulating region disposed between the first and second high concentration impurity regions.

35. The switching circuit device of claim 1, wherein the first and second high concentration impurity regions are embedded in the insulating region of the substrate and the insulating region extends from a side of the first or second high concentration impurity region by at least 10 μm, the side being substantially normal to sides of the first and second high concentration impurity regions facing each other through said portion of the insulating region.